can be either in the form of an alert or in the form of a storm warning. Typically, a storm alert is put out in the afternoon before 3:30 or 4:00 p.m. when the maintenance people go home. This gives the regular day crew a chance to prepare equipment for a night storm and to alert or schedule crews for a night storm duty.

From 4 to 6 hr before a storm is expected to begin, the independent weather service will telephone the following detailed information to subscribers:

- the approximate hour the storm will begin;
- the type and amount of precipitation expected;
- the duration of the storm;
- the temperatures, wind direction and velocity, and drifting conditions during and after each storm;
- the approximate hour of change from snow to rain, ice to rain, snow to ice, etc.; and
- weather conditions to be expected after the storm, particularly whether the temperature will go up or down.

Details of this information are transmitted by phone and recorded on forms similar to the one shown in Figure 4. The subscriber has a large number of these forms, which he fills out when called by the weather service. Transmission of the information in numerical form saves time and prevents possible errors. For storms beginning during the night, subscribers are called before 4:00 p.m. the previous afternoon with details of the forecast at that time. If details are unobtainable before about 4:00 p.m., an alert is telephoned in lieu of the detailed forecast. This same procedure is generally followed for storms which are expected to begin over the weekend.

For large subscribers such as the Massachusetts Department of Public Works, specialized forecasts are prepared. These may be transmitted over teletype to the subscriber who cuts a transcription tape of his own for transmission over a closed-circuit teletype system to major road divisions. For other large subscribers, the information may be transmitted by facsimilie. From this type of weather forecast, a specific weather map can be drawn for the particular locality of the subscriber like the New Jersey Turnpike, which has considerable variation in weather conditions from one end to the other. For other subscribers, an extended weather forecast can be provided as on the form shown in Figure 5.

The independent weather service emphasizes direct communication with maintenance managers. Individual subscribers can call the independent weather service at any time and consult with the forecasting meteorologist who is on duty at the time. This two-way communication is as important to the forecaster as it is to the subscriber. The forecaster can pinpoint exactly

NORTHEAST WEATHER SERVICES

Bedford Massachusetts Telephone (617) 275 8860

DATE JAN. 25, 19- TIME 10:30 A.M.

GIVEN BY _____ RECEIVED BY _____

AREA _____ DISTRICT _____

Snow & Ice -- Storm Warning

THE FOLLOWING WEATHER FORECAST INFORMATION IS PROVIDED FOR THE EXCLUSIVE USE OF THE SUBSCRIBER AND IS NOT AUTHORIZED FOR FURTHER DISTRIBUTION

SNOW

- ☑ 1 Snow ☐ Continuing
- ☐ 2 Snow Flurries
- ☐ 3 Snow to Ice
- ☐ 4 Snow to Rain
- ☐ 5 Snow and Ice Mixed
- ☐ 6 Snow and Rain Mixed
- ☐ 7 Rain to Snow

TYPE OF SNOW

- ☑ 8 Drifting
- ☐ 9 Fluffy
- ☑ 10 Dry (below 30°F)
- ☐ 11 Very Dry (below 20°F)
- ☐ 12 Wet (30° 34°F)
- ☐ 13 Melting (over 34°F)
- ☑ 14 Becoming
- ☐ 15 Dry (below 30°F)
- ☑ 16 Very Dry (below 20°F)
- ☐ 17 Wet (30°-34°F)
- ☐ 18 Melting (over 34°F)

TOTAL SNOW ACCUMULATION

- ☐ 19 Little, if any (Trace)
- ☐ 20 Less than 1 Inch
- ☐ 21 1 2 Inches ☐ Near 1 Inch
- ☐ 22 1-3 Inches
- ☐ 23 2-4 Inches
- ☐ 24 3-6 Inches
- ☑ 25 4-7 Inches
- ☐ 26 6-9 Inches ☐ Additional
- ☐ 27 8 12 Inches
- ☐ 28 10-15 Inches
- ☐ 29 12 18 Inches
- ☐ 30 Over 18 Inches

ICE

- ☐ 75 Ice (Freezing Rain)
- ☐ 76 Ice (Freezing Drizzle)
- ☐ 77 Sleet (Ice Pellets)
- ☐ 78 Ice to Rain
- ☐ 79 Ice to Snow
- ☐ 80 Rain to Ice
- ☐ 81 Drizzle to Ice

TYPE OF RAIN OR DRIZZLE

- ☐ 82 Hard Freezing (below 25°F)
- ☐ 83 Freezing (25°-32°F)
- ☐ 84 Borderline (30°-34°F)
- ☐ 85 Non freezing (34°-40°F)
- ☐ 86 Mild (over 40°F)
- ☐ 87 Becoming
- ☐ 88 Hard Freezing (below 25°F)
- ☐ 89 Freezing (25° 32°F)
- ☐ 90 Borderline (30°-34°F)
- ☐ 91 Non freezing (34°-40°F)
- ☐ 92 Mild (over 40°F)

EFFECTS OF RAIN OR DRIZZLE

- ☐ 93 Brief Icing (3 hrs or less)
- ☐ 94 Prolonged Icing (more than 3 hrs.)
- ☐ 95 Part Washout of New Snow
- ☐ 96 Total Washout of New Snow

SPECIAL PROBLEMS

- ☐ 97 Slush Freezing
- ☐ 98 Sharp Temperature Drop
- ☑ 99 Snow Drifting after Storm
- ☐ 100 Snow, 2" or more per Hour
- ☑ 101 Rush Hour Problems
- ☐ 102 Catch Basin Flooding

DURATION OF STORM

- ☐ 147 Less than 3 Hours
- ☐ 148 3-6 Hours ☐ Additional
- ☐ 149 6 12 Hours
- ☐ 150 12-18 Hours
- ☑ 151 18 24 Hours
- ☐ 152 Over 24 Hours

WIND

- ☐ 153 Light and Variable
- ☑ 154 Becoming
- ☐ 155 5-10 m p h
- ☐ 156 10 20 m p h
- ☑ 157 20-30 m p h
- ☐ 158 Over 30 m p h
- ☑ 159 Gusty
- ☑ 160 N
- ☑ 161 E
- ☐ 162 S
- ☐ 163 W

☑ 164 Shifting to

- ☑ 165 N
- ☐ 166 E
- ☐ 167 S
- ☑ 168 W

WEATHER AFTER STORM

- ☐ 169 Sunny
- ☑ 170 Partly Sunny
- ☐ 171 Cloudy
- ☐ 172 Snow Flurries
- ☐ 173 Thawing Days (above 40°F)
- ☐ 174 Thawing Nights (above 40°F)
- ☐ 175 Melting Days (above 32°F)
- ☐ 176 Melting Nights (above 32°F)
- ☐ 177 Below Freezing Days
- ☐ 178 Below Freezing Nights
- ☑ 179 Below 20°F All Day
- ☐ 180 Below 10°F All Day
- ☑ 181 Windy (over 25 m p h)
- ☐ 182 Snow or Ice Storm within 24 Hours

ALERT FOR POSSIBLE TROUBLE

PROBABILITY OF SNOW OR ICE STORM

- ☐ 183 90 Percent Certain
- ☐ 184 75 Percent Certain
- ☐ 185 60 Percent Certain
- ☐ 186 Less than 50 Percent Certain

CONDITIONS DEVELOPING COULD FAVOR

- ☐ 187 Snow (amount uncertain)
- ☐ 188 Snow (1 inch or less)
- ☐ 189 Snow (1-3 inches)
- ☐ 190 Snow (2-4 inches)
- ☐ 191 Snow (4 inches or more)
- ☐ 192 Changing from Snow to Rain
- ☐ 193 Changing from Rain to Snow
- ☐ 194 Changing from Snow to Ice
- ☐ 195 Ice Storm
- ☐ 196 Changing from Ice to Rain
- ☐ 197 Changing from Rain to Ice

REASON UNABLE TO DETAIL FORECAST

- ☐ 198 Storm Could Skirt Your Area
- ☐ 199 Timing Uncertain
- ☐ 200 Borderline Temperatures
- ☐ 201 Snow Accumulation Doubtful

PROBABLE BEGINNING TIME OF TROUBLE

- ☐ 202 Within 3-6 Hours
- ☐ 203 Within 6-12 Hours
- ☐ 204 Within 12 18 Hours
- ☐ 205 Within 18-24 Hours
- ☐ 206 Within 24-36 Hours

CANCEL EARLIER FORECAST OR ALERT

- ☐ 207 No Snow or Ice Expected

FORM NUMBER 20 WR

SNOW BEGINNING		1-3" BY		ICE BY		RAIN BY	
☐ 31	Mon	☐ 53	Mon.	☐ 103	Mon	☐ 125	Mon
☐ 32	Tues.	☐ 54	Tues.	☐ 104	Tues.	☐ 126	Tues.
☐ 33	Wed	☐ 55	Wed	☐ 105	Wed	☐ 127	Wed
☐ 34	Thurs	☐ 56	Thurs	☐ 106	Thurs	☐ 128	Thurs.
☑ 35	Fri	☑ 57	Fri	☐ 107	Fri	☐ 129	Fri
☐ 36	Sat	☐ 58	Sat	☐ 108	Sat	☐ 130	Sat
☐ 37	Sun	☐ 59	Sun	☐ 109	Sun	☐ 131	Sun
☐ 38	12 2	☐ 60	12 2	☐ 110	12 2	☐ 132	12 2
☐ 39	1 3	☐ 61	1 3	☐ 111	1 3	☐ 133	1-3
☐ 40	2 4	☐ 62	2-4	☐ 112	2-4	☐ 134	2-4
☐ 41	3 5	☐ 63	3 5	☐ 113	3-5	☐ 135	3-5
☑ 42	4-6	☐ 64	4-6	☐ 114	4-6	☐ 136	4-6
☐ 43	5 7	☐ 65	5 7	☐ 115	5-7	☐ 137	5-7
☐ 44	6-8	☐ 66	6-8	☐ 116	6-8	☐ 138	6-8
☐ 45	7-9	☐ 67	7 9	☐ 117	7 9	☐ 139	7-9
☐ 46	8-10	☑ 68	8 10	☐ 118	8-10	☐ 140	8-10
☐ 47	9 11	☐ 69	9 11	☐ 119	9 11	☐ 141	9 11
☐ 48	10-12	☐ 70	10-12	☐ 120	10-12	☐ 142	10-12
☐ 49	11-1 (Noon)	☐ 71	11-1 (Noon)	☐ 121	11-1 (Noon)	☐ 143	11-1 (Noon)
☐ 50	11-1 (Mid)	☐ 72	11-1 (Mid)	☐ 122	11-1 (Mid)	☐ 144	11-1 (Mid)
☐ 51	A M	☐ 73	A M	☐ 123	A M	☐ 145	A M.
☑ 52	P M	☑ 74	P M.	☐ 124	P M	☐ 146	P M.

Courtesy of Northeast Weather Services, Bedford, Massachusetts.

FIGURE 4 WEATHER REPORTING FORM

1 ☐ DAILY FORECAST
2 ☐ PRELIMINARY FORECAST
3 ☑ FORECAST
4 ☐ SUPPLEMENTARY
5 ☐ REVISED FORECAST
6 ☐ WEEK END OUTLOOK

NORTHEAST WEATHER SERVICES

131A Great Road Bedford Massachusetts 01730

Telephone (617) 275 8860

Date JAN. 25, 19-
Time 7:30 AM
Received by
By

For exclusive use of subscriber further dissemination is not authorized

FIRST DAY MON			GENERAL WEATHER	• TEMP	WINDS	GUSTS	
7		MID-3AM					
8		3AM 6AM					
9		6AM 9AM					
10	✓	9AM NOON	BECOMING CLOUDY	26	NE 10		
11		NOON 3PM					
12	✓	3PM 6PM	LIGHT SNOW DEVELOPING	30	NE 10-15		LESS 1"
13		6PM 9PM					
14	✓	9PM MID	MODERATE SNOW	28	ENE 20	30	2-4"
15	✓	REMARKS.	* Temperatures relate to the last hour of the 3-hour Forecast Period				

CONSIDERABLE BLOWING AND DRIFTING SNOW

SECOND DAY TUE			GENERAL WEATHER	• TEMP	WINDS	GUSTS	
16		MID 3AM					
17		3AM 6AM					
18	✓	6AM 9AM	LIGHT SNOW	20	NW 5	25	5-8"
19		9AM NOON					
20	✓	NOON 3PM	CLEARING	22	NW 20	35	6-9"
21		3PM 6PM					
22	✓	6PM 9PM	FAIR	14	NW 15	30	
23		9PM MID					
24		REMARKS	* Temperatures relate to the last hour of the 3-hour Forecast Period.				

✓ THIRD DAY WED	✓ FOURTH DAY THU	✓ FIFTH DAY
FAIR - COLD	FAIR - CONTINUED COLD	INCREASING CLOUDINESS
MAX TEMP: 28° MIN TEMP: 0/-5°	MAX TEMP: 18° MIN TEMP: 0/-5°	MAX TEMP: 26° MIN TEMP: 15°

FORM 101D

Courtesy of Northeast Weather Services,
Bedford, Massachusetts.

FIGURE 5 EXTENDED WEATHER FORECAST

what is happening during a storm and sharpen the local forecast in that area. This technique is particularly useful for prediction of changes in storm conditions as a storm passes between regular observation stations. It also gives the subscriber a chance to make his feelings known particularly when the weather is not what is forecasted.

A listing of independent weather services can be found in the bulletin of the American Meteorological Society, 45 Beacon Street, Boston, Massachusetts.

Local Television and Radio Stations

Many local radio and television stations maintain staff meteorologists who, with access to the standard government weather information, provide general weather forecasts for the local area served by the particular station. These forecasts are often used in conjuntion with other forecasting sources in formulation of an overall picture of the weather situation confronting the local snow and ice control group.

Other Sources of Weather Information

1. Sometimes independent meteorologists are employed to provide the precise weather predictions required of snow and ice control operations.

2. A telephone call to a neighboring highway organization may provide the required warning of snow conditions descending upon the area.

3. Often times through monitoring of a radio station in an adjacent state, sufficient warnings of snow conditions can be obtained particularly when storms follow traditional weather patterns. Supervisors of the western sections of the Massachusetts Turnpike regularly tune in on a Hartford, Connecticut radio station, which has a weather report that they find reliable.

TRAFFIC CONDITIONS AND LEVEL OF SERVICE

Two other major factors in decisions about snow and ice control are the traffic conditions that will exist at predicted start of the storm, during the storm, and at the end of the storm and the level of service to be maintained on the various classes of roads. The time at which storm conditions begin to develop has an important bearing upon the response and each group must establish a set of priorities to be followed as storms develop. (It is essential to give these priorities wide publicity so that the driving public will understand what is happening and give their support by staying home or avoiding lower serviced roads.)

Priorities for level of service should be based on traffic volume because it reflects the degree of difficulty in snow and ice control, the speed of vehicles using the roads, and the skill and familiarity of the highway users traveling on these roads. Volume of traffic also reflects the number of people that will be inconvenienced by deteriorating road conditions. Often, level of service priorities are established (quite validly) by

experience or tradition. Minnesota, Michigan, Washington, New York, Nova Scotia, and other jurisdictions have established levels of service based on average daily traffic (ADT). The levels of service used in Minnesota are given in Table 1. Levels of service will be used in this manual as the basis for standards for snow and ice control, rate of application of chemicals and abrasives, and allocations of equipment and manpower. The recommended generalized priority system includes the four classifications of roads in Table 2. The guidelines for levels of service in Table 2 are a distillation of information from all of the above sources and can serve as a stepping off point for the preparation of levels of service suited to each particular location.

Table 1. LEVELS OF SERVICE FOR SNOW AND ICE CONTROL

Courtesy of Minnesota Department of Highways

Classification	ADT	Level of Service*
Urban Commuter	Over 10,000	Bare pavement within 6 hours after termination of storm (12 hours for severe storms).
Rural Commuter	2,000-10,000	Bare pavement within 24 hours after termination of storm. (On divided highways, left lanes should be half bare with sanded curves and hills before termination of snow removal effort.
Primary	800-2,000	Intermittent bare pavement, clear Wheel Tracks (compacted snow with appropriate sanding allowed in towns and sheltered areas).
Secondary	400-800	Two bare wheel tracks and sanded hills and curves.
Secondary	250-400	Bare left wheel track and sanded hills and curves.
Secondary	Under 250 & Gravel Roads	Compacted snow is acceptable.

*Based on an average snowstorm of four inches falling in a six to eight hour period. Standards apply only to the mainline and interchange roadways, frontage road, crossover and other clean-up operations are not included.

Table 2 GUIDELINES FOR LEVELS OF SERVICE IN SNOW AND ICE CONTROL

Road Classification	Level of Service	Snow Depth to Start Plowing (Inches)	Max Snow Depth on Pavement (Inches)	Full Pavement Clear of Snow After Storm (Hours)	Full Pavement Clear of Ice After Storm Hours
1. Low-Speed Multilane Urban Expressway	• Roadway routinely patrolled during storms • All traffic lanes treated with chemicals • All lanes (including breakdown lanes) operable at all times but at reduced speeds • Occasional patches of well-sanded snow pack • Roadway repeatedly cleared by echelons of plows to minimize traffic disruption • Clear pavement obtained as soon as possible	0.5 to 1	1	1	12
2. High-Speed 4-Lane Divided Highways Interstate System ADT greater than 10,000	• Roadway routinely patrolled during storms • Driving and passing lanes treated with chemicals • Driving lane operable at all times at reduced speeds • Passing lane operable depending on equipment availability • Clear pavement obtained as soon as possible	1	2	1.5	12
3. Primary Highways Undivided 2 and 3 lanes ADT 500 -- 5000	• Roadway is routinely patrolled during storms • Mostly clear pavement after storm stops • Hazardous areas receive treatment of chemicals or abrasive • Remaining snow and ice removed when thawing occurs	1	2.5	2	24
4. Secondary Roads ADT less than 500	• Roadway is patrolled at least once during a storm • Bare left-wheel track with intermittent snow cover • Hazardous areas are plowed and treated with chemicals or abrasives as a first order of work • Full width of road is cleared as equipment becomes available	2	3	3	48

CHAPTER IV

ACTIONS

Up to this point, this manual has been concerned with the regulatory frameworks, the supervision requirements, and some of the decision-making processes that lead up to snow and ice control operations. This chapter is written for the highwaymen (the equipment operators, the foremen, and the supervisors) who get out into the storm and do the work. It deals with organization of operations, pre-season training and equipment inspection, mobilization of men and equipment, issuing of orders, guidelines for application of deicing chemicals, and precautions to be taken in handling of deicing chemicals and loading spreader trucks. It discusses the role of the spreader operator, techniques for minimizing chemical applications, and accounting procedures for keeping track of the use of chemicals.

BEING PREPARED

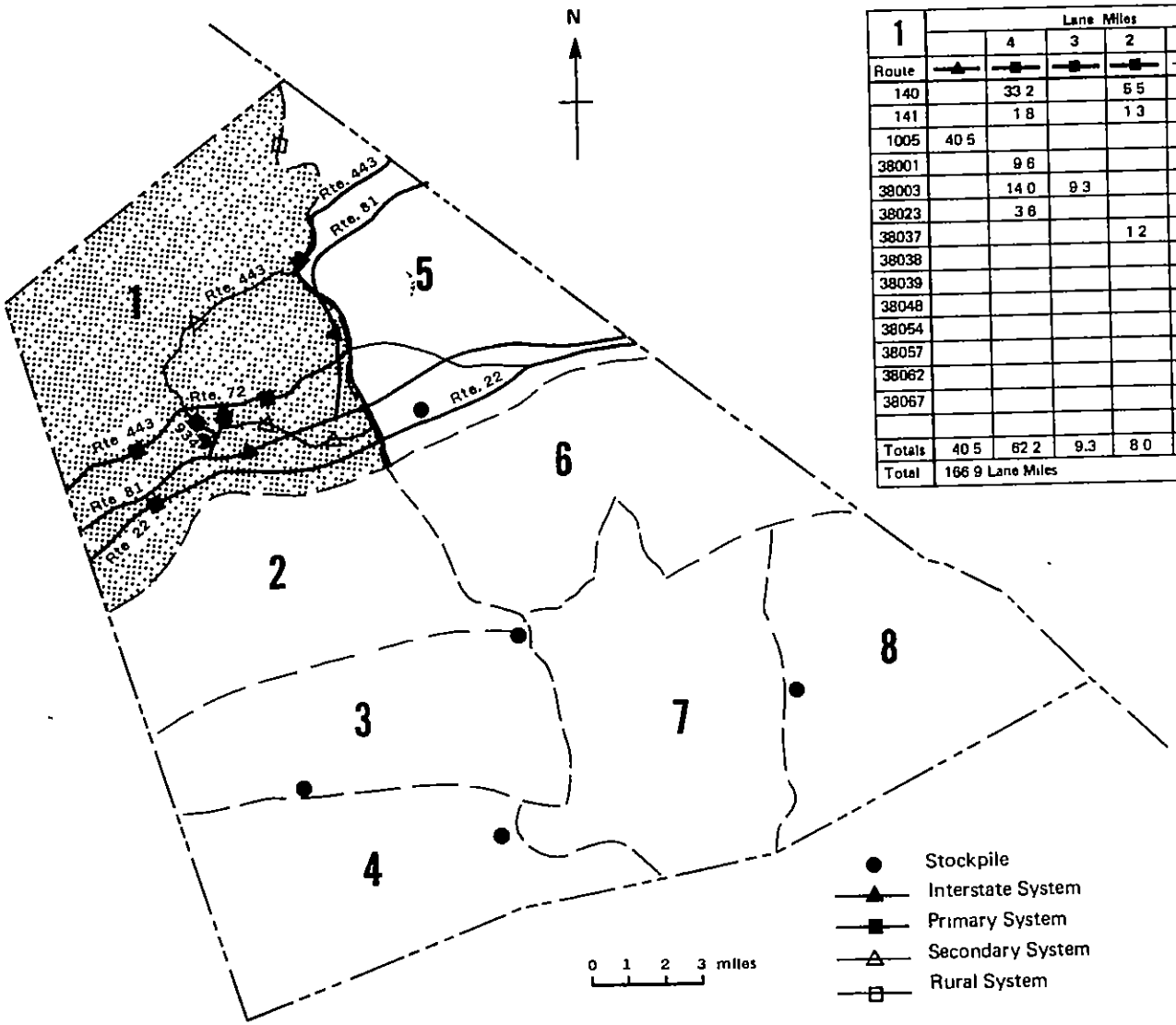
An important part of snow and ice control is the preparation of men and equipment for the actions that must be taken when weather conditions turn bad. Essential to the effective program is an organization that is responsive to the levels of service established in Chapter III.

Organization of Operations

As was pointed out in Chapter II, the work organization at the district level is the same no matter what the organization (a town or city or an integrated or a separate function within a state organization). The activities at this district level are of primary interest to us in this Chapter.

Uniform criteria must be used in establishing levels of service standards throughout the jurisdiction. At the district level it is highly recommended that both work breakdown and man and equipment assignments be based on an overall level of service plan. A good example of this is the district-level organization developed by the Pennsylvania Department of Transportation (Penn DOT) and reproduced here with its permission.

Within Penn DOT, the basic unit of organization is the county. Each county, which contains approximately 1,000 lane miles of road, is broken up into a number of foreman sections, such as the eight shown in Figure 6. Each of these eight foreman sections contains approximately 120 lane-miles of road, classified as interstate, primary, secondary, or rural and rated for level of service in that order. For simplified presentation, detail is shown for only foreman section 1. Color coding of levels of service as used by Penn DOT instead of the symbol codes shown here, increase the ease with which these planning maps can be read during storm operations.



1	Lane Miles					
		4	3	2		
Route	▲	■	■	■	△	□
140		33 2		6 5		
141		1 8		1 3		
1005	40 5					
38001		9 8			2 2	
38003		14 0	9 3			10 0
38023		3 6				
38037				1 2		
38038					3 6	
38039					10 0	
38048					6 4	
38054					2 4	4 2
38057					3 4	
38062						2 5
38067						2 2
Totals	40 5	62 2	9.3	8 0	28 0	18 9
Total	166 9 Lane Miles					

FIGURE 6 COUNTY SNOW REMOVAL PRIORITY MAP

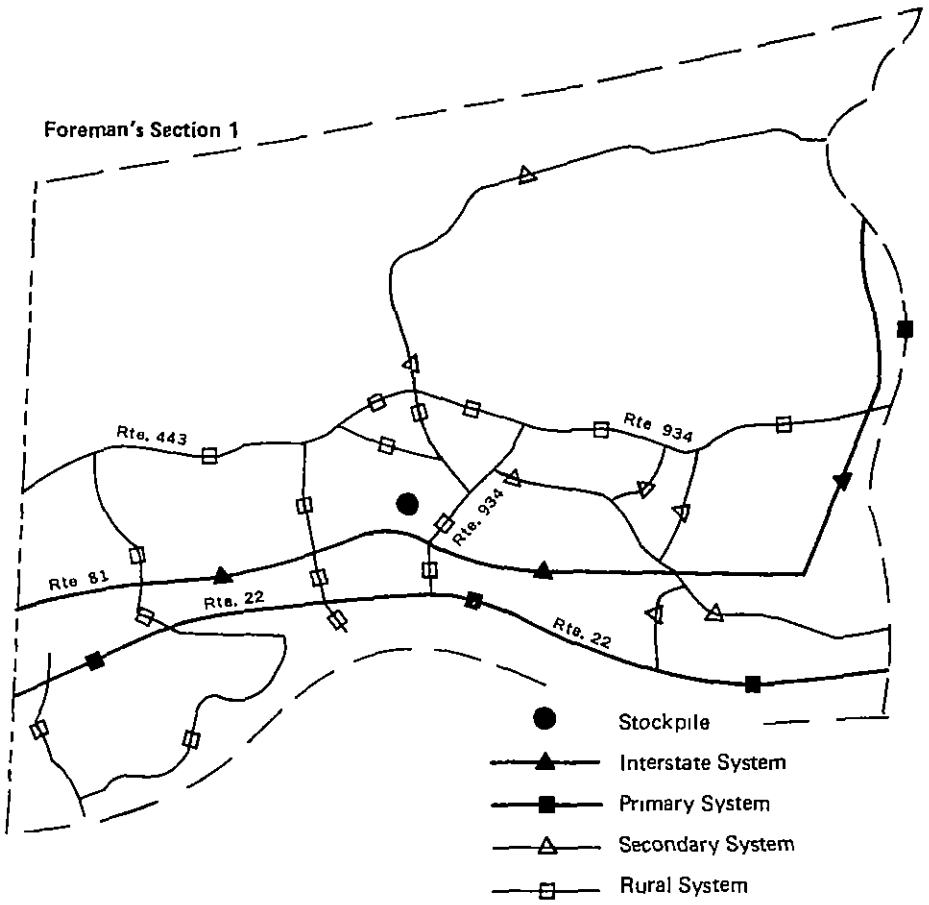
Within the foreman section, equipment assignments are made in accordance with the priorities established as shown in Figure 7. On this summary figure is all of the information the foreman will need, including stockpile locations, operator's names, the lane miles to be covered by each piece of equipment, the equipment number or rental agreement number, the equipment type, and the telephone number of the operator. Additional information includes the radio call number of the supervisor, the stockpile number and the name and telephone number of the assistant superintendent.

The third breakdown in this organization, shown in Figure 8, again shows the foreman section map and outlines the individual operator's route. This map is kept in the cab of each vehicle along with the calibration data for the spreader, and helps provide a continuity of service if road assignments have to be switched.

A work breakdown such as the one shown is based on a level of service for which the county maintenance manager has classified roads as primary, secondary, and rural, and has established appropriate service priorities. This classification is often made on the basis of the ADT, or sometimes simply on the experience of the maintenance manager.

Penn DOT's system is more elaborate and detailed than traditional methods of organization. But it has several advantages. It organizes in a common format much of the data which supervisors need in order to manage. It increases the probability that prescribed standards will be applied and followed throughout a large area; this promotes not only efficiency in use of supplies, but also the uniformity of winter road conditions which drivers should have for reasons of both convenience and safety. Personnel within the department, whether drivers or top managers, can be transferred from one job to another but still have guidance from common operating instructions applied to each county, section, and route. A related advantage, from both driver and managerial viewpoints, is that each truck driver knows what is expected of him by his supervisors in the very top of the chain of command, but the zone of discretion can be clearly limited and understood. This system also enables managers to pinpoint responsiblities, an important attribute of any organization. Moreover, it presents a mass of important data in compact yet clear form, which can aid managers in expanding both their strategy and their tactics to outside examiners, whether from other government agencies, the legislature, or the public. Finally, this clearly-presented system makes easier the inevitable process of change and adjustment.

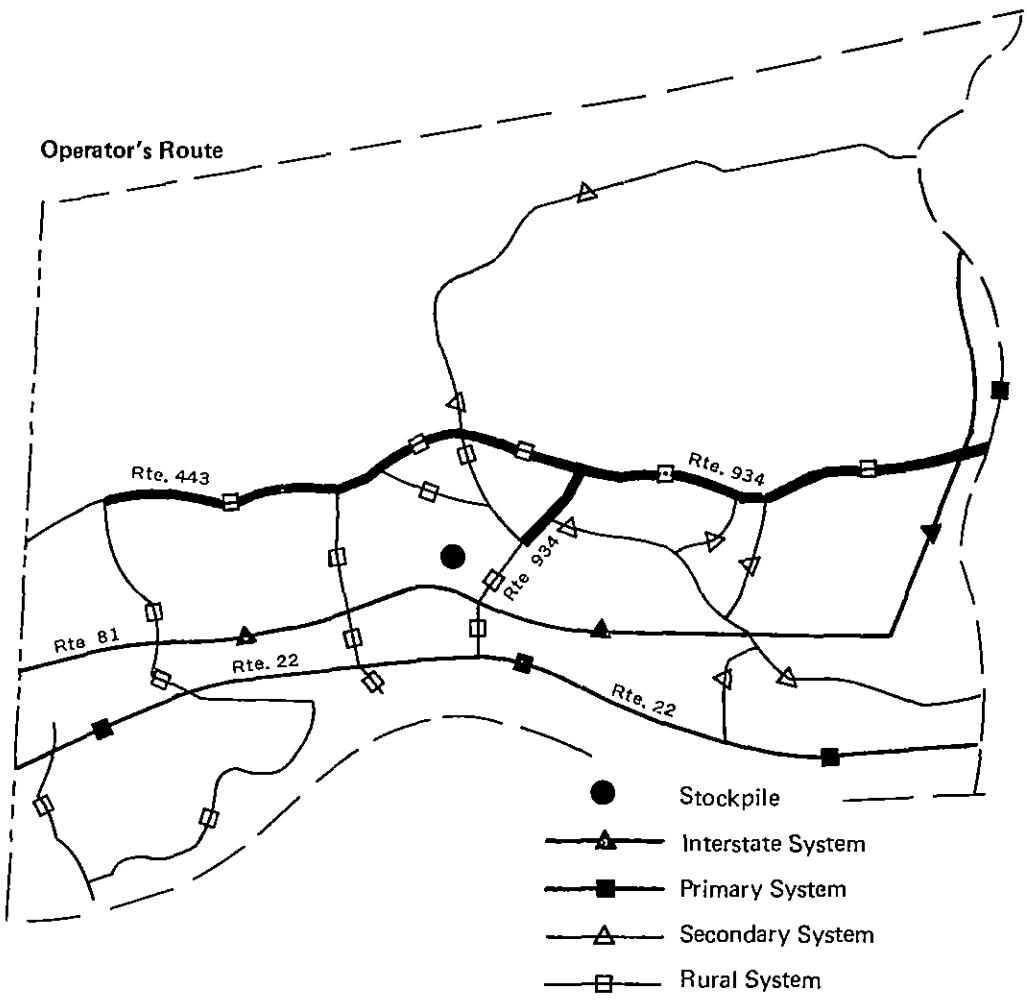
In this organization, the responsibility for maintaining roads is located at the foreman's level because he and his equipment operators are in the best position to judge the condition of the road, to see how the weather conditions are affecting the road surface, and to observe the traffic conditions. Almost all vehicles are equipped with two-way radios so that instant communication can be maintained with the section foreman. With this communication, the section foreman as he patrols his section, can be appraised of developing road conditions, of breakdowns, and of the progress in plowing or spreading of chemicals; he can reassign equipment in the event of breakdown or if level-of-service priorities have to be modified.



Key	Name	Lane Miles	Equipment No. or Agreement No.	Telephone No.	Type Eq.
●	P. Harrison	Stock Pile	178–1046	665–2049	L
—▲—	R Kastler	40.5	377–6672	665–4489	G
—▲—	A. Catino	40.5	308–4089	665–3111	P/S
—▲—	J. Metzger	40 5	576–4066	665–3681	P/S
—▲—	K Leonard	40.5	Rented Hopper	673–8139	S
—■—	B Friksen	38.7	Rented	665–4746	G
—■—	L. Champey	38 7	274–4081	665–3478	P/S
—⊟—	G Krassner	30.0	806–2066	665–3693	P/S
—△—	E Coburn	27.4	866–4067	665–4565	P/S
—⊟—	T. McNulty	30.3	371–4067	665–2431	P/S

Foreman – T. O'Leary
Assistant Superintendent – P Daniker

FIGURE 7 FOREMAN'S SECTION MAP



Key	Name	Lane Miles	Equipment No. or Agreement No.	Telephone No.	Type Eq.
	G. Krassner	30.3	806–2066	665–3693	P/S

FIGURE 8 OPERATOR'S ROUTE MAP

When rented equipment is used within a division, all equipment and accessories should be ready for use by November 1. Within the terms of their contract, rented trucks are employed to supplement equipment of the jurisdictions (state, county, or town). Such rental equipment is called out as needed during storms and used in the same manner as any state-owned equipment. Each piece of rental equipment should be given a definite work assignment under a specific foreman who supervises that equipment and is responsible for its performance. The foreman should have the responsibility for calling out the rented equipment, checking its time of arrival and departure, arranging for changing its plow blades, allowing time out for the operator's meals, changing his work assignments temporarily, loading of materials, and ensuring effective use of the equipment.

Pre-Season Crew Training and Equipment Inspection

Probably the most important action that maintenance managers can take to ensure that their winter maintenance operations are effective, is to review operations in a series of pre-season training sessions for all personnel. Everyone should be included in these pre-season training sessions, including managers, supervisors, equipment operators and their helpers, time keepers, mechanics, and, of course, all of the contractor supervisors and equipment operators.

All aspects of the winter maintenance program should be covered to some degree in each training session, although the focus of particular training session programs can be adapted for the audience. Management aspects may be emphasized at the supervisors meeting, and equipment-operation aspects may be emphasized for those personnel who are responsible for the field operations. Attendance at these pre-season training sessions should be required, and groups should be chosen so that older, more experienced employees attend along with the first-time new employees. Throughout each training session, questions and discussion should be encouraged so that the operation is fully understood and improvements can be suggested.

The techniques that can be utilized in pre-season crew training include classroom instruction, shop demonstration, equipment dress rehersals, and finally route familiarization. All of these techniques should be used to some degree in each program and should be tailored to the particular need of the organization responsible for the winter maintenance program. The program can begin as early as September, depending upon when the winter season begins, and continue right up until the winter season begins. Although efforts should be made to complete the program before November 1, training should be considered as an on-going, ever-changing function, which can continue throughout the winter season as new information or techniques are brought to the attention of the winter maintenance organization.

Classroom Instruction

All training sessions should be tailored to small groups (five to ten participants at a time) so that the instruction can be personalized and questions and discussions encouraged. Instruction material should be

prepared by the parent organization so that uniformity is guaranteed throughout the jurisdiction.

Some of the techniques that have been employed by various organizations, are listed below in descending order of preference:

- Seminars prepared and executed by the parent organization with slides and movies,
- Seminars conducted by local supervisors including slides with coordinated sound tracts or slides with a tape recorder,
- Slides with a text prepared by the parent organization, and
- Discussions of local operations and standard procedures.

Topics to be covered at these sessions include;

- Winter working hours and shift rotations;
- Mobilization;
- What to do and when to do it under varying weather conditions;
- Coordinating operations with weather changes, traffic conditions, and time of day;
- How to run a spreader;
- Quantities of chemicals and/or abrasives for varying weather conditions;
- Where to spread chemicals on the road;
- Calibration of spreaders; and
- Hazards to the environment.

Table-top demonstration models are useful for demonstrating plowing techniques. One town utilizes a model truck with plow to show employees how and how not to plow snow. The model operates on a street mock-up, which includes the difficult plowing situations that may arise including a cul-de-sac, and various types of intersections including multi-street, curbs, driveways, and straight road sections. Dry sand or soap powder simulates the snow. Each person is given a chance to "drive" the plow truck.

Shop Demonstration

Another effective tool in the training session is the shop demonstration during which pre-snowfall instruction can be given on spreader operation, plow maintenance and hook up, and spreader calibration. In these shop

demonstrations, an instructor (in this case an experienced operator) can demonstrate to each new operator how to mount a plow and properly adjust it for the various weather conditions and how to prepare a spreader for the different materials and rates of application that are expected in the winter operation program. Under supervision, each new operator must perform these functions on the specific piece of equipment which he will be responsible for using during the winter season.

These shop demonstrations should also include the calibration of a spreader. For details of spreader calibration see Chapter VI.

Equipment Dress Rehearsal

Following procedures used by the Minnesota and Michigan Highway Departments, all equipment in a section should be mobilized on one day for a formal equipment inspection and dress rehearsal. In order to stress the importance of this inspection, managers at all levels must be involved. These inspections are usually conducted by personnel from the head maintenance office.

The purpose of this inspection is to determine if the equipment is in proper mechanical condition for the coming winter season. A detailed and complete inspection is made of each piece of equipment. All accessories are checked thoroughly, and the general condition of the equipment is noted on the Equipment Pre-Season Checklist shown in Figure 9. Minor repairs are made, and major work is scheduled for a later date by the shop foremen.

Route Familiarization

The last step in the training program should enable the operator and his helper or wing-plow man to become thoroughly familiar with the section or sections or road over which he is to operate. Frequent stops should be made to inspect obstacles such as guard rails, manhole covers, and curb stones, which may cause damage to equipment if struck. High stakes with reflectors or perhaps just a tall branch should be attached to these obstructions so that the operator can identify them under the adverse weather conditions experienced during storms. Remember, the obstacle that is visible when the leaves are beginning to fall will probably be invisible or extremely difficult to spot from a plow or spreader when the weather conditions are poor.

Where to Get Additional Information

Several organizations have devoted considerable thought and efforts to develop effective training programs for winter maintenance personnel. They are aware of both the operational and the environmental problems and, through these programs, have addressed the issues.

The Salt Institute has produced an effective program entitled "Sensible Salting" that can be incorporated into a pre-season crew training program. Sensible Salting programs are conducted by skilled personnel from the Salt Institute and include the following:

ENGINE COMPARTMENT

Oil leaks - valve covers, oil pan, filter housing, lines, etc. ( )

Oil level and condition ( )

Power steering pump - belt, condition & adjustment, fluid level ( )

Cooling system

- Coolant level ( )
- Coolant specific gravity protected to -___°F ( )
- Radiator condition - leaks ( )
- Radiator hoses condition - leaks ( )
- Heater hoses condition - leaks ( )
- Fan belt - condition & adjustment ( )
- Fan blade - looseness, cracks ( )
- Water pump - seal, bearings ( )
- Radiator shutters - condition & operation ( )

Electrical system

- Battery - holder, hold downs, caps missing ( )
- Battery cables - tightness, corrosion ( )

	1	2	3	4	5	6
• Electrolyte level	( )	( )	( )	( )	( )	( )
• Electrolyte specific gravity	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

- High rate discharge test - battery amp/hr rating
  - Time discharged ( )
  - Amperes ( )
  - Minutes ( )
  - Final voltage ( )
- Alternator
  - Belt - condition & adjustment ( )
  - Lubrication (if necessary) ( )
  - Wiring - condition & tightness ( )
  - Voltage regulator - mounting, wiring ( )

Brake system components

- Hydraulic
  - Master cylinder - condition, fluid level ( )
  - Lines - leaks & condition ( )
- Air
  - Compressor - lubrication, air & cooling lines tight ( )
    - Belt - condition & adjustment ( )
  - Intake filter - condition & clean ( )

FIGURE 9 PRESEASON EQUIPMENT CHECKLIST

Fuel system (gas)

- Carburetor - mounting, leaks, etc. ( )
  - Air cleaner - condition, ducts ( )
- Fuel pump - tightness, leaks ( )
- Fuel filter - drain water, clean or replace element ( )

Fuel system (diesel)

- Air cleaner - condition & service ( )
- Transfer pump - condition & leaks ( )
- Injection pump - condition & leaks ( )
- Injectors - condition & leaks ( )
- Filters - condition & service ( )

Ignition systems

- Coil - condition & clean ( )
- Distributor
  - Cap - condition & clean ( )
  - Rotor - condition & clean ( )
  - Points & condenser - condition & adjustment ( )
- Primary wiring - condition & tightness ( )
- High tension wires - condition & tightness ( )

Clutch master cylinder - condition, fluid level ( )

Windshield washer tank - fill ( )

Front mounted hydraulic pump - condition & leaks ( )
- Clutch - operation & adjustment ( )

Steering box - fluid level check ( )

With engine running

- Engine governor settings ( )
- Air pressure governor settings ( )
- Voltage regulator settings ( )
- Engine timing settings ( )

CHASSIS INSPECTION

Steering

- Wheel bearings - condition, adjustment & lubrication ( )
- Steering box - seals, bearings, adjustment ( )
- Drag link - tightness, lubrication ( )
- Bell crank - tightness, lubrication ( )
- Tie rod - tightness, lubrication ( )
- Steering arms - bent, tightness ( )

FIGURE 9 CONTINUED

- Power steering cylinder - condition & tightness ( )
- Alignment
  - Toe in ( )
  - Caster ( )
  - Camber ( )
  - Travel stops ( )

Brakes

- Air

	Front		Rear Front Bogie		Rear Rear Bogie	
	R	L	R	L	R	L
• Actuators	( )	( )	( )	( )	( )	( )
• Lines	( )	( )	( )	( )	( )	( )
• Hoses	( )	( )	( )	( )	( )	( )
• Adjustors	( )	( )	( )	( )	( )	( )
• Quick release valves	( )		( )		( )	

  - Air reservoir - leaks, relief valves, lines ( )
  - Safety reservoir - leaks, relief valves, operation ( )
- Hydraulic
  - Booster - leaks, operation ( )

	Front		Rear Front Bogie		Rear Rear Bogie	
	R	L	R	L	R	L
• Hoses	( )	( )	( )	( )	( )	( )
• Lines	( )	( )	( )	( )	( )	( )

- Parking brake - operation & adjustment ( )

Springs

	Front		Rear Main		Rear Auxiliary	
	R	L	R	L	R	L
• Mounts, clamps, pins	( )	( )	( )	( )	( )	( )
• Springs	( )	( )	( )	( )	( )	( )
• U-bolts	( )	( )	( )	( )	( )	( )

Truck frame - bent, cracks, loose ( )

- Plow frame - loose, bent, cracks, elongated bolt holes ( )
- Wing plow frame - loose, bent, cracks, elongated bolt holes ( )
- Underbody scraper
  frame - loose, bent, cracks, elongated bolt holes ( )

Clutch - condition & adjustment ( )

Transmission(s) mounting - leaks, lubrication level ( )

Drive shaft(s) U-joints - carrier bearings, lubrication ( )

FIGURE 9 CONTINUED

Exhaust system - mounting, corrosion ( )

Fuel tank(s) - mounting, lines, gauges, caps, leaks ( )

Hydraulic oil reservoir - mounting, lines, gauges, caps, leaks ( )

Rear end(s) & power divider (if used) - mounting, lubrication level ( )

Miscellaneous component mounting (hydraulic pumps, P.T.O., etc.) ( )

- Condition - mounting, operation ( )

Tires & wheels - check tread, sidewalls, inflation, wheels bent, cracked, lug nuts tight ( )

- Tires

	Front		Rear							
			Front Bogie				Rear Bogie			
			R		L		R		L	
	R	L	In	Out	In	Out	In	Out	In	Out
• Condition	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
• Inflation	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
• Wheels	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
• Lug nuts	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

Dump body - condition & operation ( )

- Tail gate - condition & operation ( )

Spreader - general condition, controls, operation ( )

- Auxiliary engine (if used) ( )
- Flight conveyor - chain, bars, shafts, sprockets, etc. ( )
- Spinner - condition, operation ( )
- Baffles - gate, top screen, condition & operation ( )
- Hydraulic motors & lines - condition & leaks ( )
- Lubrication - gear reduction, shafts, sprockets, etc. ( )

Front plow

- A-frame - bent, broken ( )
- Lift piston - mounting, lines, leaks ( )
- Swing pistons - mounting, lines, leaks ( )
- Trip mechanism - condition & operation ( )
- Cutting edge - worn, bent, broken ( )

Wing plow - general condition ( )

- Hoist mechanism - condition & operation ( )
- Swing mechanism - condition & operation ( )

FIGURE 9 CONTINUED

Underbody scraper - mounting, bent, cracks ( )

- Lift mechanism ( )
- Trip mechanism ( )
- Cutting edge ( )

CAB CHECK

General condition of body, fenders, hood, grill, running boards, etc. ( )

- Glass - windshield, side & vent windows, rear window ( )
- Doors - latch, handles, condition & operation ( )
- Seats - upholstery, adjustment ( )
- Floorboards - padding trim ( )

Heater & defroster - condition, output, leaks ( )

- Fan switch ( )
- Cable controls ( )
- Hoses & ducts ( )
- Auxiliary fan defroster ( )

Switches & lights - condition & operation

	High		Low	
	R	L	R	L
• Headlight & dimmer switch	( )	( )	( )	( )

	Front		Rear	
	R	L	R	L
• Turn signals	( )	( )	( )	( )
• Tail lights			( )	( )
• Brake lights			( )	( )
• Parking lights	( )	( )		
• Cab markers				( )
• Clearance lights	( )	( )	( )	( )
• Plow & sander lights				( )
• Rotating beacon				( )
• Spotlight				( )
• Interior cab light				( )
• Map light				( )
• Courtesy light				( )

Instruments

- Speedometer ( )
- Tachometer ( )
- Ammeter ( )
- Temperature gauge ( )
- Fuel gauge(s) ( )
- Oil pressure gauge ( )

FIGURE 9 CONTINUED

- Air pressure gauge ( )
- Low air-pressure warning buzzer ( )
- Miscellaneous gauges ( )

Driving controls

- Steering wheel - condition & operation ( )
- Clutch pedal - operation & adjustment ( )
- Brake pedal - operation & adjustment ( )
- Accelerator pedal - operation & adjustment ( )
- Transmission lever(s) - 2-speed button, operation ( )
- Parking brake - operation & adjustment ( )
- Horn - operation ( )
- Windshield wipers - operation ( )

2-way radio - check all frequencies, operation & interference ( )

Plow controls

	Raise	Lower	Float	Swing
• Front plow	( )	( )	( )	( ) ( )
• Wing plows	( )	( )	( )	( ) ( )
• Underbody plow	( )	( )	( )	( ) ( )

Spreader controls

- Ground-speed controller ( )
  - Calibration check ( )
  - Operation - all ranges ( )
  - Manual override ( )
- Manual operation ( )
  - Calibration check ( )
  - Conveyor control - operation, repeatability ( )
  - Spinner control - operation, repeatability ( )

Emergency & safety equipment

- First aid kit ( )
- Fire extinguisher ( )
- 4-6 fuses ( )
- Reflector flares ( )
- Shovel ( )
- Tire chains ( )
- Tow chain cable ( )
- Red flags ( )
- Wing push bar ( )
- Wing push bar shear pins ( )
- Flashlight ( )
- Light kit ( )
- Wheel chocks ( )

FIGURE 9 CONTINUED

- A movie on snow and ice control operations,
- A movie on calibration techniques,
- Discussions concerning snow and ice control operations,
- Demonstrations of the calibration of a spreader (usually performed on a spreader belonging to the host organization), and
- Additional information to be supplied by the Salt Institute

The New England Chapter of the American Public Works Association has developed a training film designed to improve snow plowing operations. The film is about a snow school designed to help eliminate the common mistakes in snow plowing and combines classroom demonstration with a model snow plow and a table-top model of common street plowing situations and actual street plowing scenes combined with descriptions of good plowing techniques.

The Michigan Department of State Highways has developed two internal training programs for snow and ice control. One program concerns how much salt to use and where to put the salt when spreading it. The other program concerns calibration of spreaders and is based principally upon Salt Institute's Sensible Salting Program.

MOBILIZATION

As it becomes increasingly clear that bad weather is on the way, warning must be given so that men and equipment can be ready. The warning procedures in Chapter III indicate how supervisors or their designated alternates can be directly notified by phone that snow and ice control actions will probably have to be initiated. Acknowledgement of this notification is usually required and is logged by the weather warning personnel.

Each road section must be provided with at least 3, and preferably 4 hours of warning along with a description of the magnitude of the storm so that crews can be alerted and materials and equipment can be prepared for the particular weather expected. The exact time for mobilization is, of course, the responsibility of the road section supervisor.

Thus, the most important warning is the first or preliminary warning that bad weather is on the way. At this time, the supervisor makes his decision about what to do and when to do it based on past experience with similar warning. For instance, he may elect to apply chemicals or abrasives and/or wait for snow to accumulate and then plow.

The degree of mobilization will probably depend upon the magnitude of the storm. For a large, full-scale storm, the entire road section crew may be mobilized including truck spreader operators, front-end loader operators, wing plowmen, laborers, foremen, and mechanics. For a small storm or one

that begins at night, just the spreader operators may be required, and they will load their own trucks.

ISSUING OF ORDERS

The road section supervisor has responsibility for issuing orders concerning both mobilization of manpower and equipment and the application rate for deicing material. He is responsible for interpretation of the weather reports and the road conditions at hand, prescription of the application rate for deicing chemicals or abrasives, and the initiation of plowing operations. These orders are usually issued verbally to the foremen and then in turn to the equipment operators who adjust their spreaders for the amount prescribed and attach the requisite plows as needed.

APPLICATION RATE FOR DEICING MATERIAL

The amount of deicing material that must be applied to improve the driving conditions on a particular section of highway at any specific time during a given storm is dependent primarily on the weather, the traffic conditions, and the level of service to be maintained. From an environmental point of view, the minimum amount to be applied would be no chemicals--clearly not an acceptable alternative except perhaps on little-used rural roads. From the point of view of improved driving conditions, an amount equal to or slightly in excess of a not-yet-determined minimum should be used. Unfortunately, no generally accepted guidelines have been established for minimum amounts of chemical to be applied for different weather and traffic conditions. Furthermore, no experimental programs have been conducted to determine the minimum amount of chemicals required--a condition that has been long recognized by many maintenance managers.

Those guidelines that are presently being used have evolved from the point of view of improving the driving conditions. Until there is widespread concern for the environment on the part of the driving public (see Part Five of this manual) or until the demand for bare roads at all times is diminished, these guidelines will not change significantly. In addition, since existing guidelines have not been verified experimentally, they have simply been found to be adequate.

The critical environmental issue is not the exact amount of chemical material that is prescribed for a given set of weather, traffic, and road capacity conditions, but rather that no more than the recommended prescribed amount be used (a matter of equipment calibration) and that a minimal number of applications be made during each storm (a matter of weather prediction and supervision of the operation).

A major finding of the study leading up to the writing of this manual was that many agencies did not know how much salt or deicing chemical was being spread with each application and, in most instances, the amount was not only greater than expected but also greater than the amount prescribed. This startling fact was revealed in many agencies when,

for either financial or ecological reasons, a concerted effort reduced the use of chemicals yet did not reduce the level of service or the driving conditions.

General Guidelines

In view of all of these limitations, suggested guidelines for chemical application rates are given in Table 3. These guidelines reflect the lower limits of chemical usage in current practice among a wide range of city, town, county, state, and toll-road authorities. Five classifications of roads comprise the basic parameters. The guidelines are presented in terms of the amount of material that is to be spread upon a mile of two-lane road or per mile of two lanes of a divided highway. How this material is to be spread on the highway must be determined by each agency.

Generally, chemicals such as salt (sodium chloride) and/or premixes of salt and calcium chloride are spread in a narrow pattern in the center of two-lane roads or on the crown of multi-lane divided highways. On super elevated curves, the material should be placed as high as possible on the curve so that the brine produced will flow across the road surface. Under some conditions a full width pattern is required particularly on heavily traveled roads where all lanes carry equal traffic.

In some agencies, particularly on secondary roads, the material is not spread but simply placed in a windrow right on the centerline of the highway where the melting action produces brine which will flow in both directions across the road. In the case of abrasives, a larger spread pattern is generally used in order to obtain good coverage of both driving lanes either on a two-lane road or on a multi-lane highway. Care must be exercised during spreading to ensure that material is not spread into the breakdown lanes or onto the shoulders where it is not effective.

The New York State Department of Transportation has developed guidelines for spreading of deicing chemicals that call for an initial application of material at the beginning of storms followed by applications at a lower rate on an as-needed basis. The initial application forms a brine on the road surface which prevents bonding of snow and ice and the subsequent buildup into snow pack. The smaller applications, particularly when made immediately after plowing (often by the plow trucks itself), maintain this film of brine at the road surface. The last small application is made when the storm is almost finished and is beneficial in drying the road particularly if a temperature drop occurs at storm's end.

The quantities prescribed in Table 3 are for two-lane roads; when single lanes are being treated, such as exit ramps and acceleration lanes, the rates should be half of those stated in Table 3. Reducing this rate should be the duty of the spreader operator or his assistant and is an important environmental consideration, particularly for large cloverleaves at the junction of multi-lane highways where there is a large, concentrated usage of deicing chemicals.

Table 3 GUIDELINES FOR CHEMICAL APPLICATION RATES

WEATHER CONDITIONS			APPLICATION RATE (Pounds of material per mile of 2-lane road or 2-lanes of divided)			
Temperature	Pavement Conditions	Precipitation	Low-and High-Speed Multilane Divided	Two and Three-Lane Primary	Two-Lane Secondary	INSTRUCTIONS
30°F and above	Wet	Snow	300 salt	300 salt	300 salt	- wait at least 0.5 hour before plowing
		Sleet or Freezing Rain	200 salt	200 salt	200 salt	- reapply as necessary
25-30°F	Wet	Snow or Sleet	initial at 400 salt repeat at 200 salt	initial at 400 salt repeat at 200 salt	initial at 400 salt repeat at 200 salt	- wait at least 0.5 hour before plowing; repeat
		Freezing Rain	initial at 300 salt repeat at 200 salt	initial at 300 salt repeat at 200 salt	initial at 300 salt repeat at 200 salt	- repeat as necessary
20-25°F	Wet	Snow or Sleet	initial at 500 salt repeat at 250 salt	initial at 500 salt repeat at 250 salt	1200 of 5:1 Sand/Salt; repeat same	- wait about 0.75 hour before plowing; repeat
		Freezing Rain	initial at 400 salt repeat at 300 salt	initial at 400 salt repeat at 300 salt	1200 of 5:1 Sand/Salt; repeat	- repeat as necessary
15-20°F	Dry	Dry Snow	plow	plow	plow	- treat hazardous areas with 1200 of 20:1 Sand/Salt
	Wet	Wet Snow or Sleet	500 of 3:1 Salt/ Calcium Chloride	500 of 3.1 Salt/ Calcium Chloride	1200 of 5:1 Sand/Salt	- wait about one hour before plowing; continue plowing until storm ends; then repeat application
below 15°F	Dry	Dry Snow	plow	plow	plow	- treat hazardous area with 1200 of 20:1 Sand/Salt

Included in Table 3 are the timing of applications and suggested waiting periods between chemical application and the initiation of plowing. This waiting period is critical from the points of view of operations, improved driving conditions, and the environment because it allows the deicing chemical to form a brine, spread out on the highway, prevent bonding of precipitation (snow, sleet, or freezing rain) and to be dissolved completely in this process before plowing occurs. Premature plowing will pick up the material in undissolved form and deposit it on the shoulder where it is of no use in improving the driving conditions. In short, when deicing chemicals are used, the philosophy should be to use them fully and not throw them away.

Oftentime highway men are confronted with a problem of changing weather conditions. This emphasizes the need for close monitoring of the weather and judging what the weather will do on the basis of past experience with similar storms. This is where the skill of maintenance managers is crucially important. When changes in weather conditions are predicted, the supervisor should take these changes into account when prescribing the material and quantities. For instance, if there is a high probability of rising temperature, the amount of material prescribed should be reduced in anticipation of the temperature rise. Likewise, if the temperature is predicted to drop rapidly at the end of a storm, it is important to get a final application of salt down so that the road will dry up as the storm ends and so that icy patches cannot form.

Environmentally Critical Areas

Some agencies are consciously reducing the amount of material that is used in environmentally critical areas, such as watersheds used for water supply. Several courses of action are open in these areas.

First of all, the level of service of roads in these areas can be lowered, particularly on primary and secondary roads. Care should be taken to notify motorists that there will be a reduction of the level of service in these areas.

Next, the amount of salt used can be reduced by application of smaller amounts and less frequently. Some jurisdictions are reducing the amount of sodium that enters such environmentally critical areas by using mixtures of salt and calcium chloride in ratios of 3:1 or 5:1 salt to calcium chloride.

Prewetting of the salt has been used in order to accelerate the action of salt, and at the same time to utilize less total material. These salt prewetting schemes usually use materials that do not freeze at extremely low temperatures, such as solutions of salt, calcium chloride, methyl alcohol, or propylene glycol.

The North Dakota Highway Department has successfully prewetted salt with water alone sprayed on top of the loaded truck at a rate of 18-20 gallons per cubic yard of salt. Salt brine pumped from an area drainage catchment basin can also be used for prewetting salt. Care must be exercised when

using water or dilute solutions in sub-freezing weather to keep water hoses and pumps from freezing. A prewetted load of salt must not remain in the truck for a prolonged period during sub-freezing weather because it will freeze.

The prewetting material of choice by some agencies is a 32% (by weight) solution of calcium chloride (4.12 lbs of 94-97% CaCl in 1.0 gal of water, or 5.79 lbs of 77-80% $CaCl_2$ in 1.0 gal of water). Several techniques are used for applying it to the salt. In some jurisdictions, calcium chloride solution is pumped onto the dry load of salt before the truck driver proceeds along his route. In Iowa, Michigan, New York, and others, a tank of calcium chloride solution is carried on the truck, and the calcium chloride solution is dispensed into the discharge chute of the spreader either by means of a pump or under gravity. The object is to coat thoroughly each particle of salt with calcium chloride solution before it is applied to the snow or ice on the road; this can initiate immediate melting of the snow or ice to form additional brine that dissolves the crystals of salt. Prewetting keeps the salt from bouncing off the roadway during spreading and from blowing away once it is on the road. A typical application rate for prewetting of salt as it is dispensed at the back end of a spreader is at 8 gal per ton. For calcium chloride solutions applied beforehand to a full load of salt in the truck, a typical application rate is 10 gal per ton, and the material is pumped onto the top of the load just before the truck leaves the yard.

Connecticut's Bureau of Highways has been experimenting in 21 critical watershed areas with several mixtures of sand, salt, calcium chloride, and 50/50 mixture of propylene glycol to accelerate the action of the salt and calcium chloride. The three mixtures being used are summarized in Table 4. Mixture One containing no sand, is used on the interstate highways where they pass through these watersheds. The standard Connecticut premix (3:1 salt/calcium chloride) is spread at a rate of about 430 lb per two-lane mile and is prewetted with a 50-50 mixture of propylene glycol and water at a rate of 10 gal per two-lane mile. Mixture Two uses 11 parts sand and two parts of standard premix. This mixture is prewetted with 10 gal per mile of 50-50 propylene glycol water mixture. Of the three mixtures being used Mixture Two, as noted in Table 4, contains the smallest amount of salt and calcium chloride. Mixture Three is made from seven parts sand and two parts of standard premix. No propylene glycol is used for prewetting of this mixture.

Additional Techniques for Minimizing Chemical Applications

In one way or another, all of the techniques outlined in this manual are directed toward minimizing the amount of deicing chemicals and/or maximizing the effect of those chemicals that are used. As many of these techniques should be incorporated as possible, appropriate, and economically feasible.

During each winter storm, the optimum chemcical application rate is a combination of many factors including the level of service, weather conditions changing with time, the state and characteristics of the chemicals used, the time of application relative to both changing traffic and weather

Table 4 MIXTURES FOR ENVIRONMENTALLY CRITICAL AREAS

	Mixture 1	Mixture 2	Mixture 3
Spread Rate (lbs/mile of 2-lane road)	430	1500	1500
Description of Mixture Dry Ingredients	all 3:1 Premix	11 parts sand 2 parts 3:1 Premix	7 parts sand 2 parts 3:1 Premix
Amount of 50/50 propylene glycol	10	12	none
Calculated Quantities (lbs/mile of 2-lane road)			
• salt	320	180	260
• calcium chloride	110	45	86
• sand	---	1275	1154

3:1 Premix = 3 parts Rock Salt and 1 part Hydrated Calcium Chloride by weight

Courtesy of State of Connecticut Department of Transportation

conditions, and the topography and type of road surface. The actual determination of an application rate by a maintenance manager is a matter of his best judgment. Usually the rate is chosen that will reasonably cover as many of the uncontrollable variables as possible.

Many noteworthy techniques have been developed by maintenance managers who are attempting to minimize the application rates for deicing chemicals and abrasives, and/or to maximize the deicing effect of those materials applied. In the following listing, are some additional techniques that were noted during the course of the study preceding the writing of this manual.

- Application of chemicals should occur in smaller increments in response to changing traffic and weather conditions. Although this requires more attention by operators, foremen, and other maintenance managers and much more intensive use of equipment, the techniques guards against the possibility of unnecessary over-application of environmentally harmful chemicals.

- Abrasives should be used with little or no use of chemicals in locations where traffic is not heavy enough to remove them rapidly from the road. A mixture of 20 parts of sand and one part salt (the minimum amount required to keep a sand pile from freezing) often results in sufficient melting action to provide an adequate level of service on secondary roads and roads in residential areas.

- For storms that are expected to produce heavy snowfalls, application of salt at the onset of the storm followed by early and continued plowing throughout the storm will provide an adequate level of service, particularly if it is followed by a light application of salt at the end of a storm in order to clear up the road and prevent freezing when the temperature drops.

- Less chemicals are required to prevent snow pack from forming if underbody scrapers are used extensively in the plowing program. These scrapers can clear the road surface of hard-packed snow more readily than a conventional front-mounted plow.

- Through coordination of the timing of plowing and chemical applications, the salt is allowed to melt, form brine, and break the snow-ice bond at the road surface before snow is plowed off. Success of this technique requires keen observation of conditions and good communication among crew foremen and district supervisors.

- When roads are subject to regular one-way commuter traffic, both plowing and chemical applications should be concentrated on in-bound or out-bound lanes as appropriate to the peak traffic load and time of day.

- A towed spreader (see Figure 25 in Chapter V) is useful for applying concentrated and controlled amounts of chemicals to areas on the roadway (such as the passing lane) that may need additional applications in such a well-defined area that a large spreader truck would put too much material out over a too large area.

PRECAUTIONS IN HANDLING OF DEICING CHEMICALS

Once the application rate has been prescribed, the action shifts from the supervisors or managers to the men who must carefully use these deicing chemicals. A complete description of precautions concerning handling of deicing chemicals before application is given in Part III of Manual for Deicing Chemicals: Storage and Handling (EPA-670/2-74-033).[1] When the spreader trucks are being loaded before and during a storm good practices should be followed. In general, five precautions should be observed.

- If possible, load trucks or spreaders inside the salt storage shed. This reduces spillage and cleanup problems.

- Before the spreader truck leaves the shed or the loading area, clean it off--catwalks, top edges and ledges of the body, tanks, roof and fenders. This will keep the salt from spilling off where it is not wanted.

- Keep the loading area clean by immediately cleaning up any salt lying on the loading pad, and get it back under cover.

- Keep the salt dry by keeping it under cover as long as possible before loading it onto the trucks.

- Handle the salt as little as possible. Excessive handling causes large particles to break down into finer particles which reduces their effectiveness for clearing snow.

ROLE OF THE SPREADER OPERATOR

The spreader truck operator has the ultimate control over the amount of chemical that is spread on highways. The success of any program to minimize the amount of chemicals spread on highways is totally dependent on his enthusiastic acceptance of this goal. Thus, it becomes increasingly important that spreader operators be thoroughly familiar with the equipment and the desires of the foremen, supervisors, and other high officials responsible for the snow and ice control program.

Further, because he is out in the storm, the spreader operator is in the best position to judge the condition of his section of the road and the efficacy of his snow and ice control efforts, and can feed this information back to his foreman and supervisors. Maintenance of two-way radio communication with each spreader operator is as important as use of a well-calibrated, easily controlled salt spreader.

Control of the actual amount of salt spread should be in the hands of the spreader operator. He should be told by his supervisor the standard amount of salt that is to be spread on his particular run. The actual spreading rate may vary from place to place throughout the run depending upon the number of intersections, grades, and bridge decks that are subject to icing before the main road. However, as weather conditions change for better or for worse, the operator should have the option of increasing or decreasing his amounts within some limit, for instance +20 or -100 lb depending upon the weather and traffic he encounters. Before increasing the spreading amounts above this upper discretionary limit, the operator should seek guidance from his supervisor via the two-way radio. Clearly, to vary the spreading rate this way during a run requires equipment with in-cab controls which are in good operating condition.

All spreader operators should be trained to spread chemicals on the crown of the road or on the high side of the road and should know how to change spreading techniques or pattern in response to crosswinds that blow the material before it settles on the highway pavement. Further, he should know when to cease spreading chemicals and initiate a plowing operation.

Before beginning each snow control operation, the spreader operator should check out his truck thoroughly. This should be done before the spreader is loaded with chemicals. A good time to perform this inspection is when the driver is first called out or when he is called upon to attach his plow in readiness for a storm condition. Each driver should perform a preoperation walk-around inspection, checking all of the items listed in Figure 10. Upon completion of this check out, the operator can proceed to load the spreader with the assurance that his truck and spreader are in top operating condition.

ACCOUNTING FOR CHEMICAL USAGE

While careful control of the amount of deicing chemical that is spread is the primary means for minimizing the impact on the environment, a second major technique for control is the development of an accounting procedure that allows supervisors to keep track of the use of chemicals and to analyze the results obtained therefrom. The basic requirement for accounting for salt usage is knowing:

- what snow and ice control techniques were used,
- the type and amount of chemical used,
- where it was used and the number of lane miles covered,

UNDER HOOD

Lube Oil	( )
Coolant	( )
Power-steering	
pump reservoir	( )
Alcohol injector	( )
Windshield washer fluid	( )
General:	
Belts	( )
Leaks	( )
Loose components	( )

WALK AROUND

Any fluid leaks under truck	( )
Any damage or loosening of mounting bolts, etc.	( )
Turn on lights	
headlights	( )
clearance lights	( )
tail and stop lights	( )
flasher beacon	( )
plow and spreader lights	( )
Turn off all lights	
Springs	( )
Hangers	( )
Pins and U-bolts	( )
Wheel lug nuts	( )
Tire inflation	( )
Any stones between duals	( )
Plow	
trip mechanism	( )
mounting	( )
cutting edge	( )
Spreader	
any broken or loose components	( )
leaks	( )
hydraulic leaks	( )
deflector	
Hydraulic oil tank	
mounting	( )
fluid	( )
Air tank drain valve closed	( )

CAB

Start engine	
oil pressure ( ) fuel ( ) ammeter ( )	
air pressure buildup time	( )
any abnormal engine or transmission noises	( )
all cab controls	( )
odometer	( )
speedometer	( )
tachometer	( )
brake	( )
hand brake	( )
radio operation	( )
calibration chart handy	( )
supply of Operator's Daily Trip Reports	( )
pencils	( )

FIGURE 10 PRE-OPERATIONS WALK-AROUND INSPECTION

- what the weather and road conditions were, and
- what the results were.

Three major classes of winter reporting are required in a successful management program for snow and ice control.

- the operator's daily storm report,
- the road section, supervisors storm summary report, and
- the road district's annual winter activity report.

Operator's Daily Storm Report

The starting point and probably the most important input to this management control procedure is the basic data provided by a daily truck operator's report. This report of winter activities, like any report to be completed by an operator, must be easily filled out (and accurately), yet contain sufficient information for meaningful analysis. Two operator reporting forms that incorporate much needed information are shown in Figure 11 and 12. A suggested model for an operator's daily report is shown in Figure 13.

Operator's daily reports should be hand-sized forms which can fit into a shirt or coat pocket and which are printed on heavy weight, high grade paper stock suitable for field usage even under damp conditions. Each operator is responsible for filling in the report card as material is loaded onto his truck and as work is accomplished. At the end of each shift, the operator totals up his usage of material and the lane miles on which the material was spread, and submits the card to his supervisor for verification. A supply of these operator activity cards should be kept in each truck. These operator reports can be used for accounting for materials usage for purposes of resupply and restocking and by the supervisor in preparing his storm summary report.

Supervisor's Storm Summary Report

The second important report in the management control of chemical deicing compounds is the road section supervisor's storm summary report. This report can be compiled from all of the daily reports by operators covering the period of a storm and with some additional data concerning the weather, which must be gathered by the supervisor. Six important parameters should be included in the supervisor's storm summary report.

- Total materials used;
- Number of applications;
- Total lane miles;

Form 17256 (9 71)

Minnesota Highway Department

CHEMICAL USAGE LOG

Complete in duplicate at end of each shift Original to foreman, copy remains in book

Date	Route No	SHIFT HOURS
		[ ] 8 AM 4 PM
Unit No	Source	[ ] 4 PM - 12 M
		[ ] 12 M - 8 AM
Single [ ] Tandem [ ]		[ ] ____ M- ____ M

LOAD	COVERAGE Spot (%)	COVERAGE Continuous	Cu Yds of Winter Sand	Cu Yds of Chem Added	Total Cu Yds.
1	[ ]	[ ]			
2	[ ]	[ ]			
3	[ ]	[ ]			
4	[ ]	[ ]			
5	[ ]	[ ]			
6	[ ]	[ ]			
7	[ ]	[ ]			
8	[ ]	[ ]			
9	[ ]	[ ]			
10	[ ]	[ ]			
No of Times Covered		Totals			

Signature of Operator

Remarks:

Courtesy of State of Minnesota Highway Department.

FIGURE 11 OPERATOR'S CHEMICAL USAGE LOG

STATE OF MICHIGAN
DEPARTMENT OF STATE HIGHWAYS
MAINTENANCE DIVISION
Form 450 (Rev. 10/71)
OPERATORS WINTER REPORT

CREW SIZE	ACTIVITY
1	141 WINTER OPERATIONS

ROUTE(S) — EQUIPMENT FINANCIAL CODE

FOREMAN — START DATE — TIME — AM PM

OPERATOR — STOP DATE — TIME — AM PM

TRUCK # — TOTAL HOURS ACT. 141

ACCOMPLISHMENT

	LOAD		SPOT	LEFT	CONTINUOUS	
	SALT	SAND	TONS/YD	TONS/YD	TONS/YD	MILES
1						
2						
3						
4						
5						
6						
		TOTAL				

MATERIAL

DESCRIPTION	UNIT	TOTAL AMOUNT
SALT	TONS	
SAND	CY. YDS.	
CALCIUM CHLORIDE	BAGS	

Courtesy of State of Michigan
Department of State Highways

FIGURE 12 OPERATOR'S WINTER REPORT

Truck Ident. _____ Operator _____ Foreman _____

Route(s) _____ Weather _____

Start Date _____ Time _____ AM PM _____

Finish Date _____ Time _____ AM PM _____

Load		Amount Loaded Ton, Yd	Amount Remaining Ton, Yd	Net Used Ton, Yd	Mileage		Prescribed Application Rate (Lb/Mi)	Results Good Fair Poor	Remarks
No.	Type of Material				Odometer	Actual or Estimated			
1									
2									
3									
4									
5									
6									
			TOTALS						

FIGURE 13 GENERALIZED OPERATOR'S DAILY STORM REPORT

- Measures of the weather at the reporting location:
  type of precipitation (dry snow, wet snow, sleet, freezing rain, rain),
  total snowfall,
  total water content of precipitation, and
  brief description of the storm including temperatures, wind, hourly snowfall and/or precipitation rates;

- Quantities calculated from the above information (average pounds of chemical per lane mile per application); and

- Results obtained from the materials applied.

In the many state and local snow and ice control organizations contacted during this study, no storm summary report was found that included all of this above information. A suggested generalized form for a storm summary is shown in Figure 14. The supervisor in each road section is responsible for completing this type of form as soon as possible after the storm or, in the event of a series of small winter operations, at the end of each week. These storm summary reports form the basis for comparisons of the snow and ice control activities in the various road sections of larger administrations, and for development of state-wide and/or annual summaries of snow and ice control activities. The body of data should be large enough so that statistical analysis can be applied if desired.

Annual Chemical Use Report

A final report of interest to the management of snow and ice control with chemicals is an annual report of chemical consumption. Large administrations responsible for snow and ice control such as states, cities, turnpike authorities, and towns may be required to produce or may want a summary report of chemicals consumed. The important parameters for such a report might include:

- Total tons of materials used;

- The average number of applications;

- The total lane miles on which chemicals are applied;

- The total snowfall;

- The total precipitation water content;

- A summary description of all of the storms encountered that winter, including duration, dates, type;

- The calculated quantities
  average pounds of chemicals per lane mile per application and
  average pounds of chemicals per lane mile per measure of the weather such as the inches of snowfall and equivalent precipitation as inches of water;

District No.

Road Section		Material		① Total Amount (Tons)	② Total Miles of 2-Lane Roads Covered	Rate Lb/Mile of 2-Lane $\frac{2000 \times ①}{2 \times ②}$	Results
No	Length (Miles)	Type	No. Applications				
1							
2							
3							
4							
5							
6							

Description of the Weather

Time	Type of Precipitation	Cumulative Amount (in)	Temperature °F	Notes

Total Snowfall _____ (In.)

Total Precipitation (as Water) _____ (In)

Date(s) of Storm _____

Report by _____

Remarks _____

FIGURE 14 STORM SUMMARY REPORT

- Results obtained from the material applied;
- A discussion of the quality of the service provided the traveling public; and
- An estimate of the environmental impact.

Managerial Uses of Accounting Reports

These data gathering and reporting efforts must now be applied constructively to the management of the use of deicing chemicals. They should be used to produce desired levels of snow and ice control for the traveling public with a minimum of chemicals.

Because the pounds of salt applied per lane mile can be easily calculated from the operator's daily storm report, this report is most useful to the road section supervisor in determining if his operators are spreading chemicals at the prescribed rates. When this rate exceeds the prescribed amount, the supervisor can look further to determine if the equipment or the operator is at fault. This report can also be used for inventory records of chemicals used. By checking the reported usage of chemicals drawn from various storages against receipts and inventory of chemicals in these storages, the supervisor can also check the accuracy with which his operators report their usage.

The supervisor's storm summary report is used for deciding when to order replacement materials and how much, for determining if the prescribed rate for salt spreading and the number of applications each storm are providing the desired level of service, for evaluating the performance of subgroups (crews), and for fending off questions and criticisms from other managers and the driving public.

A comparison of storm summary reports from various road sections can be used for analysis of the relative efficiency of each section in terms of measures such as tons per lane mile per inch of precipitation or tons per lane mile per storm.

The annual snow and ice control summary report is useful for interpretation both by officials and by the general public. Good use can be made of this report in requesting additional funds for equipment and storage of materials for subsequent winter seasons, for discussing usages in proportion to the amount of precipitation when talking with environmental groups, and in budgeting the chemical and abrasive requirements for the following winter season (See Chapter VII).

PART FOUR: EQUIPMENT

CHAPTER V

SNOW AND ICE CONTROL EQUIPMENT

The availability of appropriate and functioning equipment and experienced personnel to operate it is the single most important element in a successful snow and ice control program. Although no two organizations have exactly the same program or approach, a commonality exists in the equipment they use. In this section general equipment requirements are discussed and major classes of equipment are described. Wherever possible, advantages and disadvantages are presented, improvements made by individual organizations are noted, and new developments underway are introduced.

EQUIPMENT REQUIREMENTS

Figuring Needs

A winter snow and ice control program for each road section requires a unique mixture of manpower and equipment suited to the average local weather and traffic conditions and the level of service to be maintained. These equipment and labor requirements are usually established over a period of years in response to weather, the level of service, and experience in providing this level of service.

In the course of this study, similarities were noted among the inventories of equipment required for similar road sections. From informal surveys made in the course of a large number of visits to organizations active in snow and ice control, guidelines are established in Table 5 for equipment. These guidelines are a generalized measure for evaluation of present operations, for preparation of budgets for new equipment procurement, and for estimation of manpower requirements for the coming winter season.

Specific equipment and labor requirements for each snow and ice control jurisdiction can be established only after consideration of numerous complex factors, including the distance in lane miles to be serviced, the number of interchanges, the average plowing and spreading speeds, and the level of service. Sometimes a formula is derived including a variety of variables for calculation of equipment requirements.

The Minnesota Department of Highways uses the following formula for calculation of required single- and tandem-axle dump trucks.[4] This requirement is directly related to lane mileage, cycle time, and number of interchanges. Cycle time is the amount allowed for snow removal on through lanes of a given road section to maintain the required level of service under average weather conditions. For interchanges, cycle time is increased to 1.5 times the figure for the adjacent mainline; one truck